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A NOTE ON THE IMPACT ON PILBARA LEAF-NOSED AND GHOST BAT ACTIVITY FROM CAVE SOUND AND VIBRATION LEVELS DURING DRILLING OPERATIONS

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ABSTRACT

Monitoring of two conservation significant bat species, the Pilbara Leaf-nosed Bat, (the Pilbara form of the Orange Leaf-nosed Bat, *Rhinonicteris aurantia*) and the Ghost Bat (*Macroderma gigas*), indicate that small colonies of both exist in the area centred within Mesa 3 of the Poondano mining project area, Pilbara, Western Australia.

Mineral exploration commonly coincides with high quality habitat for these species and habitat destruction represents a key threat to their persistence. Resource evaluation drilling operations at the ore body were carried out within the project area in November 2009. During these operations several caves used by the Ghost Bat were instrumented for sound and vibration measurement and observed for impact of drilling on bat activity. The instrumentation measured temperature, humidity, sound and vibration within the caves as drilling proceeded nearby. In addition an ultrasonic call detector was placed in one cave used by the Pilbara Leaf-nosed Bat and the Ghost Bat to monitor activity throughout the drilling operations.

When the drilling was occurring at a distance of 20 m from the cave's known inner extremity, sound and vibration disturbance levels within the caves did not cause the bats present, including Ghost Bats, to abandon the cave.

Maximum vibration levels between 0.5 to 0.9 mm/s and sound levels up to 70 dB(A) were recorded during drilling operations at 20 m distance at these caves. Levels of 0.4 to 0.6 mm/s and 60 dB(A) were recorded when drilling was occurring at 50 m distances. Baseline sound and vibration levels measured were 45 to 50 dB(A) and 0 mm/s respectively.

In one case the drilling penetrated a cavity at the rear of an unoccupied cave. This caused vibration and drill fluid spillage levels sufficient to severely disrupt bat fauna should they have been present within the cave.

It is concluded that maximum sound and vibration levels within a cave caused by ore body drilling operations at a minimum drilling distance of 50m from any known internal extension of the cave (60 dB(A) and 0.6 mm/s) will likely not result in the bats abandoning the cave.

INTRODUCTION

During a fauna survey of the Poondano mining project area in the Pilbara region of Western Australia, the presence of the Ghost Bat *Macroderma gigas* and the Pilbara form of *Rhinonicteris aurantia* (Pilbara Leaf-nosed Bat) was confirmed at Mesa 3. Under the Commonwealth EPBC Act (1999) the Pilbara Leaf-nosed Bat is Vulnerable whereas the Ghost bat is not listed. Both species are listed as conservation significant in Western Australia with the Pilbara Leaf-nosed Bat as Vulnerable under the Wildlife Conservation Act (1950) and the Ghost Bat as Priority 4 (a taxa in need of monitoring) by the Department of Parks and Wildlife (DPaW). The Ghost Bat is listed as Vulnerable by International Union for Conservation of Nature and Natural Resources (IUCN) Red List (2012).

The Ghost Bat is a large carnivorous bat at 130 g and the Pilbara Leaf-nosed Bat is a small insectivore at 9 g (Churchill 2008, Van Dyck and Strahan 2008). The resident population of Ghost Bats was estimated at approximately 30 over the period of the survey using a combination of visual searches and ultrasonic call detection systems. Approximately five Pilbara Leaf-nosed Bats were also detected.

The fauna survey was conducted over several weeks during September and October of 2009, corresponding to the latter part of the dry season. The study area consists of a line of eight ironstone capped mesas immediately adjacent to Petermarer Creek approximately 25 km east of South Hedland and 7 km south of the Great Northern Highway in the north west of Western Australia. These mesas form the first rocky upland adjacent to the coastal plain. Within these mesas, caves occur in the ironstone, just above the basal rock formation. The site is significant for both species. For the Ghost Bat a population of

this size adjacent to the coastal plain and so close to a major suburban location is unusual. For the Pilbara Leaf-nosed Bat, the number of confirmed Pilbara locations capable of supporting a population throughout the dry season is very limited (Armstrong 2001, Churchill 2008, Van Dyck and Strahan 2008).

Both the Ghost Bat and Pilbara Leaf-nosed Bat are known to use caves with specific diurnal roosting conditions (Jolly 1988, Churchill 1991, Baudinette *et al.* 2000, Armstrong and Anstee 2001). The Pilbara Leaf-nosed Bat requires day roosts in wet caves or mines where high humidity levels are maintained during the dry season to facilitate successful breeding in the wet summer season. Both species are known to forage along riparian lines of the Pilbara (Armstrong 2001, McKenzie and Bullen 2009). The Ghost Bat is able to move reasonable distances as long as alternative suitable roosts are available. In contrast, the Pilbara Leaf-nosed Bat is known to dehydrate and die within hours in the heat of the Pilbara dry season. Both species are known to reproduce early in the summer season in the Pilbara with the Ghost Bat births timed for November (Douglas 1967, Armstrong and Anstee 2000) and the Pilbara Leaf-nosed Bat timed for December (Armstrong 2001, Van Dyck and Strahan 2008).

The Ghost Bat is known to be sensitive to disturbance (Douglas 1967, Van Dyck and Strahan 2008) such as vehicle or helicopter sound after which it often temporarily leaves its roost cave (Authors' unpublished observations). Large raptors are known to target and chase if it departs from its roost cave during daylight hours after such a disturbance (Authors' unpublished observations).

Presence of these species at cave 26 on Mesa 3 was confirmed during an initial September/October 2009 survey and again during the November 2009 and February 2010 visits. During all visits, Pilbara Leaf-nosed Bat echolocation calls at this cave were detected one to two hours after sunset and then between midnight and dawn. This consistent pattern indicates that this cave supports a population of Pilbara leaf-nosed Bats by foraging or possibly roosting bats rather than hosting occasional visits. Ghost Bats were sighted roosting inside cave 26 in daytime and up to 30 of their echolocation calls per night were also recorded during the September/October survey. Additionally their presence was also recorded during the November and February visits. Ghost Bat presence at a number of other caves on the mesas was also proven during the first survey visit based on presence of middens, visual sightings and echolocation recordings. Overall, mesa 3 was found to have the highest level of Ghost Bat activity generally in the study area. Two other cave roosting bat species, the Common Sheath-tailed Bat (*Taphozous georgianus*) and the Inland Cave Bat (*Vespadelus finlaysoni*) were also

detected during the first survey in a number of the caves on the mesas, including cave 26.

Due to the known impact of disturbance on these species, this study was instigated to assess the direct effect of the noise and vibration generated by mineral deposit evaluation drilling on top of the mesa, directly above the caves containing the bats.

METHODS

Study Area

Nine caves (c2, c12, c26, c27, c29, c30, c31, c34 and c40) where Ghost Bats have been recorded previously were chosen for sound and vibration monitoring during the November 2009 visit. These caves were directly underneath the planned drill pattern and were either shown to contain Ghost Bats during the first survey visit or were deemed similar in structure. The caves were on four of the mesas. The mesas occur in an east-west line and extend over a length of approximately 4 km. Each mesa is between 200 to 400 metres long and is capped by channel-iron deposit ironstone laid down in a palaeoriver channel. The details of these locations are included in Table 1 below.

One site, cave 26 on mesa 3, where Pilbara Leaf-nosed and Ghost Bats had been detected in small numbers the previous September, was instrumented with echolocation recorders to determine whether the bats remained throughout the drilling operations. Due to the sensitivity of these species, drilling was prohibited within 50 m of the projected internal extent of this cave.

Table 1. Location of recording equipment at each cave surveyed.

Date	Mesa Number	Cave Number	Easting	Northing	Position of Transducers
5 Nov	2	12	692220	7737163	2 m inside cave
6 Nov	4	40	691301	7737106	Vibration recorded 2 m inside cave. Sound recorded at cave entrance
11 Nov	3	34	691915	7737083	2 m inside cave
11 Nov	3	31	691812	7737048	2 m inside cave
12 Nov	3	30	691700	7737046	2 m inside cave 30
12 Nov	3	29	691683	7737049	2 m inside cave 29
13 Nov	9	2	692534	7737233	2 m inside cave
13 Nov	3	26	691595	7737099	3 m within cave

Projection is GDA 94, zone 50.

Survey Timing and Weather

The sound and vibration study was conducted between 5 and 13 November 2009. This was during a hot and humid period. Each study day was fine with minimum and maximum temperatures between 25 and 40 °C. The drilling operations were supervised (by SC in capacity of Supervising Ecologist). Other than the drilling, no activities were conducted that could directly impact upon the bat fauna present.

Instrumentation

Time histories of sound and vibration levels were logged using calibrated equipment. Sound logs were recorded using an analyser/recorder (Bruel & Kjaer, Denmark, model 2250) and vibration logs were recorded using a vibration and blast-monitoring unit (Texcel, Brisbane Australia, model GTM) fitted with a tri-axial accelerometer transducer. Vibration data were corrected for a systematic bias of 0.07 mm/s apparent in the raw data at a time when there was no vibration source operating nearby. This bias was evident at the beginning of data collection on each day and at each cave. Sound data was presented as A-weighted sound pressure levels. This is the local air pressure deviation from ambient caused by the sound waves. A-weighting is a common method of presenting recorded sound data for consistent comparison with other environmental noise studies. Supplementary sound data were collected using an un-calibrated hand held sound level meter (DSE model Q1362).

Echolocation recordings were collected from cave 26 continuously from sunset to sunrise (after recommendations in Environmental Protection Authority and Department of Environment and Conservation 2010) using an Anabat II echolocation recorder (Titley Scientific Australia) connected to a digital recorder (Sony, Japan, Minidisk model MZ-NH700). COOL EDIT 2000 (now available as AUDITION from Adobe Systems Inc.) was used to display each sequence for identification.

Systematic Sampling

The contractor proposing to mine the tenement carried out a program of drilling prior to the summer season to confirm the ore grade and extent. This program was carried out using a small Reverse Circulation pneumatic percussion drill rig operating at 2400 kPa (350 psi) drilling 160 mm diameter, 10 m deep holes during daylight hours and was supervised by an ecologist. Holes were drilled at the vertices of a 10 m by 40 m grid on each mesa top. This caused a small number of holes to approach within a horizontal distance of 50m from the caves used by the target species.

Sound and vibration monitoring equipment were placed in each study cave as the drilling pro-

gram approached its location. The transducers were placed approximately 2 m inside each cave entrance except where noted (Table 1) and a short inspection was made of the cave interior to visually check for Ghost Bat presence. This distance was chosen in accordance with occupational health and safety regulations and to give representative signal levels from the cave interior without disturbing the bats roosting within the cave prior to the drilling operation. To prevent any unintended interference while observing, the ecologist was positioned between 10 and 20 m from the cave entrance during the drilling operation to observe any unusual daylight bat activity including bats visible in the cave mouth, either flying or clinging to the wall, or exiting. Following completion of the daily drilling program, the instrumentation was removed from the cave mouth and the visual check repeated.

Except for cave 26, data were recorded during daytime drilling operation at distances of 50 to 20 m, in 10 m descending intervals, from the caves innermost known extremity based on assessments made of cave depth during the first survey.

As part of the study, a night-time echolocation survey was conducted to confirm whether the two targeted species had abandoned cave 26 during the drilling operations. This survey consisted of completing overnight bat sound recordings at the cave mouth, with the detector oriented vertically, beginning at late afternoon. These recordings were made on each night from 5 to 12 November 2009. Calls by Ghost Bats and Pilbara Leaf-nosed Bats were logged.

RESULTS

Sound and vibration levels increased in each cave monitored as the drilling operations approached (Table 2). Average and maximum A-weighted sound levels recorded at the 20 m distance were of the order of 63 and 70 dB(A) respectively (Table 3).

Table 2. Effect of distance on sound and vibration levels.

	50 m	40 m	30 m	20 m
Average sound level dB(A)				
Average	52.5	54.8	55.0	63.3
Std dev	8.04	7.11	4.30	6.1
n	6	6	5	3
Maximum vibration level mm/s				
Average	0.25	0.36	0.30	0.27 Note 1
Std dev	0.24	0.32	0.35	0.19
n	5	5	5	5

Note 1. High vibration level measured when drill penetrated cave 34 is not included.

Table 3. Summary of maximum sound and vibration measurements.

Cave	Rig distance from cave while drilling m	Average vibration level at closest approach mm/s	Maximum vibration level recorded during drilling operations mm/s	Maximum sound intensity during drilling operations dB(A)	Observed structural cave damage	Observed bat activity during and after drilling operations
12	60 – 30	0.16	0.43	~58	No damage	Audible bat calls during drilling become more frequent after about 5 min. Continued for approx 10 min. No bats exited cave.
40	50 – 20	0.09	0.23	~70	No damage	No bats exited cave during drilling. Ten Ghost Bats inside C40 not disturbed.
34	50 – 30	0.21	0.88	~55	No damage	No bats present in C34
34	20	5.6	42.0	~62	Drill hit cavity at rear of cave	Drill fluid covered cave wall. Bats likely to have been disturbed if present.
31	50 – 20	0.03	0.48	~62	No damage	Audible Ghost Bat calls frequent through drilling period. No bats exited cave. Approximately thirty Ghost Bats huddled in ceiling of cave after drilling complete.
30	50 – 20	0.01	0.13	N/A	No damage	No bats exited cave during drilling.
29	50 – 20	0.02	0.20	~48	No damage	No bats exited cave during drilling. One Ghost Bat seen inside cave
2	50 – 20	0.07	0.58	~59	No damage	No bats present

Average vibration levels within the caves during general drilling operations were in the range 0.05 to 0.20 mm/s for most caves (see Table 3). The maximum vibration levels recorded at the 20 m distance from caves containing Ghost Bats, when the drill did not penetrate the cave, were in the range 0.5 to 0.9 mm/s (Table 3).

These levels compare to baseline sound and vibration levels without the drill rig operating that were 45 to 50 dB(A) and 0 mm/s respectively

No bats were observed at any cave entrance or to depart the cave being observed during the drilling operations.

Average sound and vibration levels were significantly higher at cave 34 on mesa 3 during drilling operations at 20 m distance when the drill hit a cavity at the rear of the cave. Excessive levels of sound and vibration resulted from the intrusion and a cloud of dust was visible exiting the cave. Subsequently the walls of the cave were observed to be covered in a spray of drill fluid. No bats occupied this cave, however, should any bats have been present they would certainly have been impacted by this occurrence.

The continued presence of Pilbara Leaf-nosed and Ghost Bats at cave 26 was confirmed each night during the drilling operations with the exception of Pilbara Leaf-nosed Bats on the night of 12 November (Table 4). A subsequent visit in February 2010 confirmed the continued presence of both species.

DISCUSSION

Drilling within 20 m of the roost cave resulted in sound and vibration levels that have not caused Ghost Bat or other common insectivorous bat species to exit or abandon caves. Drilling within 50 m of the known Pilbara Leaf-nosed Bat roost cave resulted in sound and vibration levels that have not caused this species to abandon cave 26. The sound levels measured, up to 70 dB(A), are

Table 4. Pilbara Leaf-nosed and Ghost Bat activity at cave 26.

Date	Cave	Time span of recording	*Rhinonicteris aurantia*	*Macroderma gigas*
5 and 12 Nov	26	overnight	Not detected	detected
6 to 11 Nov	26	overnight	2 to 8 calls detected per night	detected

Note: Continued presence of Pilbara Leaf-nosed and Ghost Bats subsequently confirmed in February 2010.

considered moderate to human hearing with the sound being roughly equivalent to a room with a radio or television operating at normal volume. Based on a history of observations of Ghost bats being disturbed by the approach of vehicles or helicopters (by RDB), we believe that disturbances of this level in conjunction with vibration of 0.9 mm/s may be approaching those that would cause the bats present to exit or abandon the caves. The result reported, that no bats exited the caves during drilling, was surprising.

Factors associated with the bats remaining in place may be the drilling being carried out during daylight hours, late dry season environmental conditions or the presence of the observer approximately 15 m from the cave entrances. It is possible that a combination of these factors overrode a tendency for the bats to depart.

The single occurrence of a drill penetrating a cave showed that this will have a major effect on any bats present within the cave, both by the spray of dust and drill fluid and also by the modification to the cave's structure. A localised roof collapse and modified ventilation characteristic, for example, may modify the internal airflow causing a change in humidity at the rear of the cave. This occurrence demonstrates that in order to avoid excessive impact to bat colonies, drilling operations must be carried out with a working knowledge of any caves containing bats in the area and the effective depth and alignment of these caves.

The results of this study show that sound and vibration levels during drilling operations at distances of 50 m from the interior of bat roost caves generate moderate sound and vibration levels that do not result in the bats abandoning the cave during daylight hours. Drilling at closer distances, i.e. 20 m from the caves interior, generate progressively higher sound and vibration levels that may be approaching levels that may cause bats to abandon caves. Sound and vibration levels will also be affected to an extent by the size and power of the drill rig employed. Larger rigs than the one used in this study may cause higher sound and vibration levels. It is therefore recommended that a minimum distance of 50 m from the known internal extent of a cave containing bats be set for future mineral resource drilling operations.

No attempt has been made during this study to include the effects of noise and vibration generated by sources other than the drilling program or to study any consequences of those individual effects. The sound and vibration levels reported here may provide an early benchmark for activities such as infrastructure or road construction where impact on bat roost caves is to be minimised.

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